# Explanation of Station Keeping Analysis

There are four plots included in this explanation to show the effects on the ability of the DP MODU to maintain station while disabling one quadrant of thrusters.

The four plots are described as:

1. Plot C1-E1 – System Intact (All thrusters operational) – One-Year Return Environment
2. Plot C1-E4 – System Intact (All thrusters operational) – Normal Winter Storm
3. Plot C3-E1 – One Quadrant Disabled (Two Thrusters out of service) – One-Year Return Environment
4. Plot C3-E4 – One Quadrant Disabled (Two Thrusters out of service) – Normal Winter Storm

Environmental Criteria is defined as:

<u>One-Year Return:</u>

- Current Speed = 0.6 knots
- Wind Speed = 26 knots
- Wave Height (Max) = 9 feet
- Vessel Draft = 55 feet

<u>Normal Winter Storm:</u>

- Current Speed = 1.5 knots
- Wind Speed = 50 knots
- Wave Height (Max) = 19 feet
- Vessel Draft = 55 feet

Plot Definitions:

- Solid Black Line = Forward Azimuth – Heading Control
- Solid Blue Line = Aft Azimuth – Heading Control
- Solid Red Line = Forward Power – Position Control
- Solid Green Line = Aft Power – Position Control
- X-axis = Percent Power Required
- Compass Axis = Incident Angle (direction the environment originates)
- Environment Note = All forces are collinear

**Plot C1-E1 Summary**

- All 8 Thrusters in Service
- Environment is One-Year Return

- Black/Blue Lines overlap
- Reg/Green Lines overlap
- 10%-12% of Power is required for heading control
- 5% of Power is required for position control

**Plot C1-E4 Summary**

- All 8 Thrusters in Service
- Environment is Normal Winter Storm
- 40% to 50% of Power is required for heading control
- 30% to 40% of Power is required for position control

**Plot C3-E1 Summary**

- One Quadrant (Two Thrusters) are out of service
- Environment is One-Year Return
- 15% to 25% of power is required for heading control (depending upon incident angle)
- 5% to 12% of power is required for position control (depending upon incident angle)

**Plot C3-E4 Summary**

- One Quadrant (Two Thrusters) are out of service
- Environment is Normal Winter Storm
- 40% to 95% of power is required for heading control (depending upon incident angle)
- 30% to 100+% of power is required for position control (depending upon incident angle)

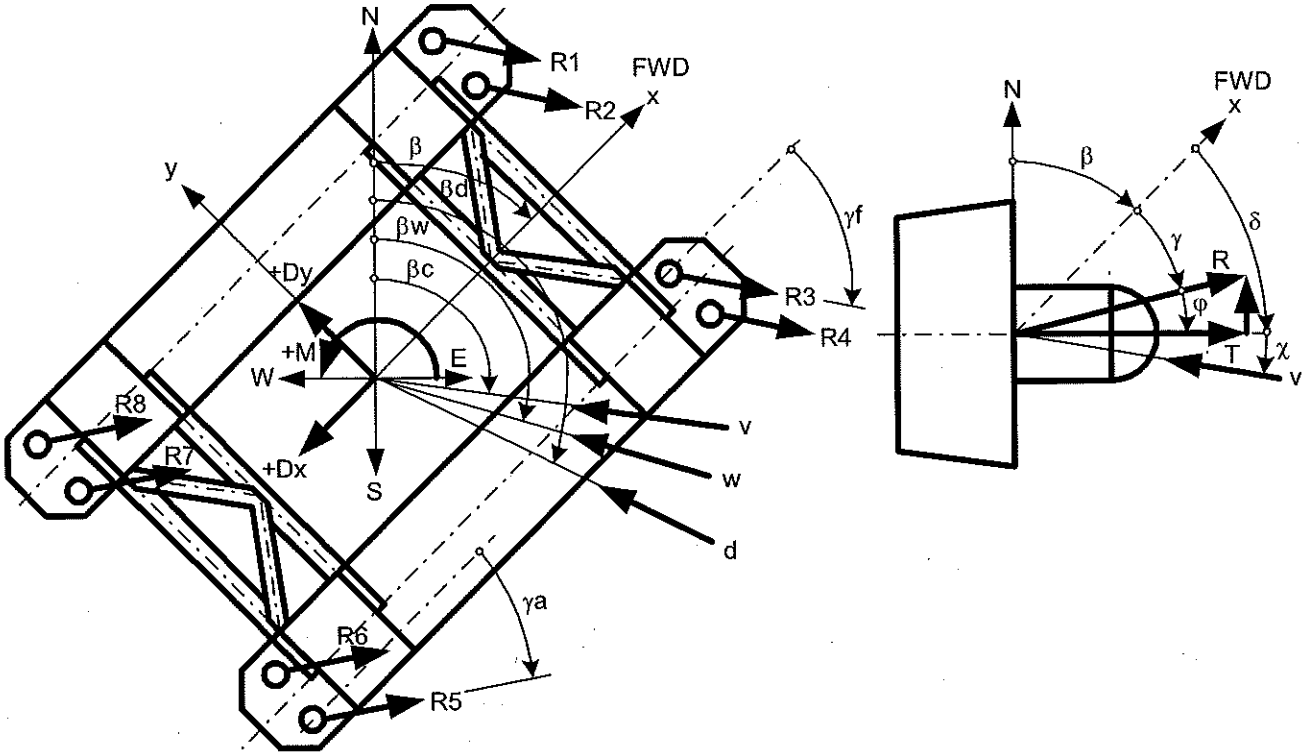
**Summary**

The above information should demonstrate the effect disabling one quadrant of thrusters has on the ability of the vessel to maintain station. Any increase in the environment over the benign, one-year return criteria drastically increases power requirements to maintain station. Due to this, normal practice is to keep all quadrants in use as the vessel is less susceptible to incident angle of the environment.

Under normal conditions, we would not disable a quadrant of thrusters while connected to the sea floor as this causes undue risk to the environment and our asset.

**PLOT C1-E1**

**Thruster Arrangement and Forces**




**Thruster Location Coordinates, Thruster Status**

| Thruster No. | Coordinates x [ft] | Coordinates y [ft] | Thruster Status e [-] |
|---|---|---|---|
| 1 | 132 | 101 | 1 |
| 2 | 132 | 69 | 1 |
| 3 | 132 | -69 | 1 |
| 4 | 132 | -101 | 1 |
| 5 | -132 | -101 | 1 |
| 6 | -132 | -69 | 1 |
| 7 | -132 | 69 | 1 |
| 8 | -132 | 101 | 1 |

Note: If Thruster is in service e = 1
out of service e = 0

**Consideration of Cross Coupled Forces**

CCF = 1

Note: With consideration of the cross coupled forces

Consideration of CTP = 0
Equal Thrust FWD and AFT

Power P0 = 3500 [HP] (nominal motor output)
Thrust T0 = 116.7 [kips] at bollard pull condition
Thrust Tv = 111.7 [kips] at current speed v

**Environmental Data**

v = 0.6 [knots] Current speed
w = 26.0 [knots] Wind speed
Hs = 9.0 [feet] Wave height
Dft = 55.0 [feet] Vessel draft
Admissible draft range Dft = 23ft ... 65ft
Admissible wave height range Hs = 0ft ... 40ft

**Incident Angle of Current, Wind, and Waves**

bc = 90 [deg] Current angle
bw = 90 [deg] Wind angle
bd = 90 [deg] Wave angle

**PLOT C1-E1**

**Environmental Data**

v = 0.6 [knots] Current speed
w = 26.0 [knots] Wind speed
Hs = 9 [ft] Wave height
Dft = 55 [ft] Vessel draft
e1 = 1 e2 = 1 e3 = 1 e4 = 1 e5 = 1 e6 = 1 e7 = 1 e8 = 1

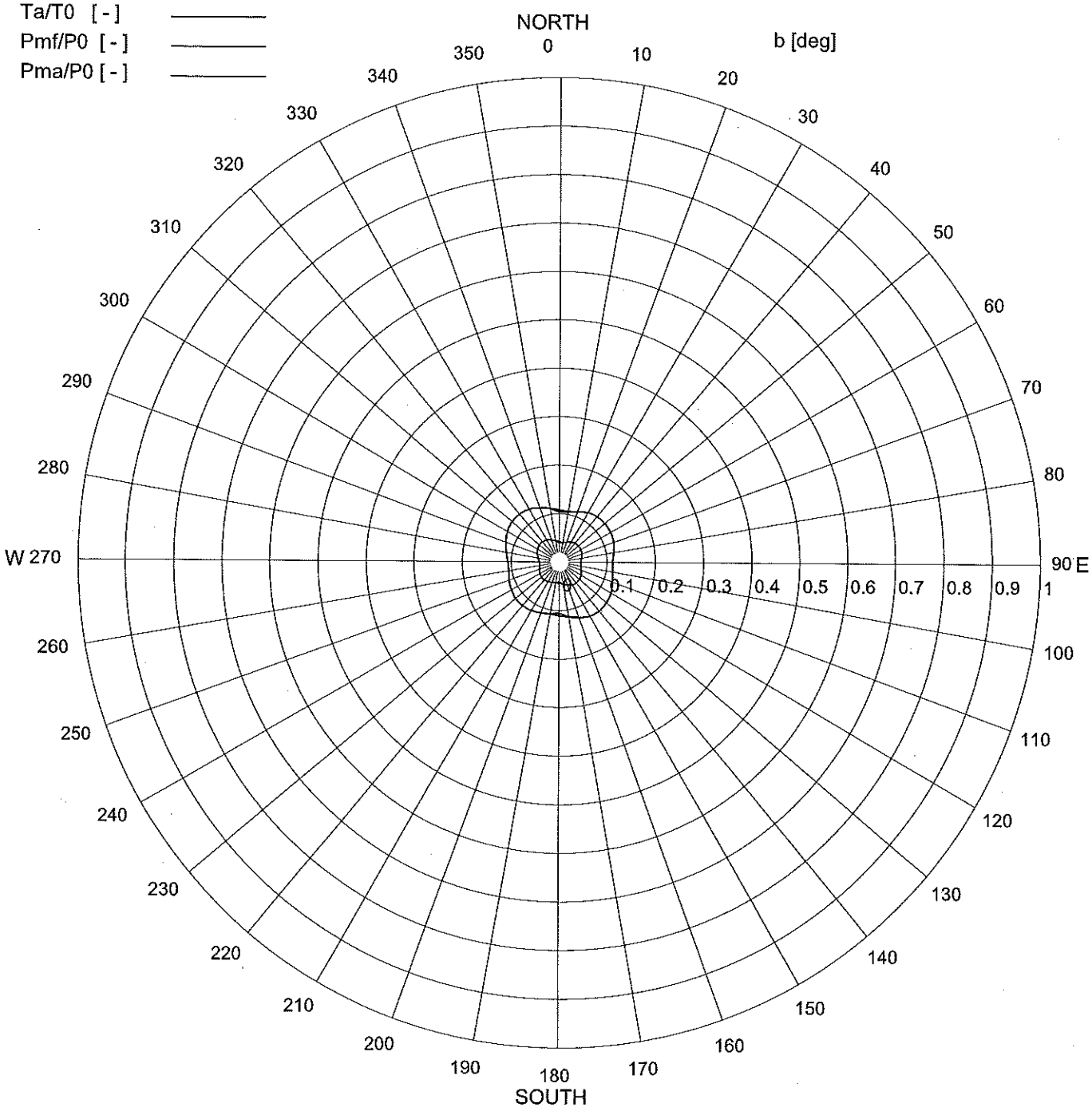
**Incident Angle**

bc = 90 [deg] Current angle
bw = 90 [deg] Wind angle
bd = 90 [deg] Wave angle

Thruster No. :
in service = 1, out of service = 0

Thrust/Bollard Pull and Motor Output/Nominal Motor Output as Function of the Heading Angle of the Vessel

Tf/T0 [ - ]
Ta/T0 [ - ]
Pmf/P0 [ - ]
Pma/P0 [ - ]



**PLOT C1-E4**

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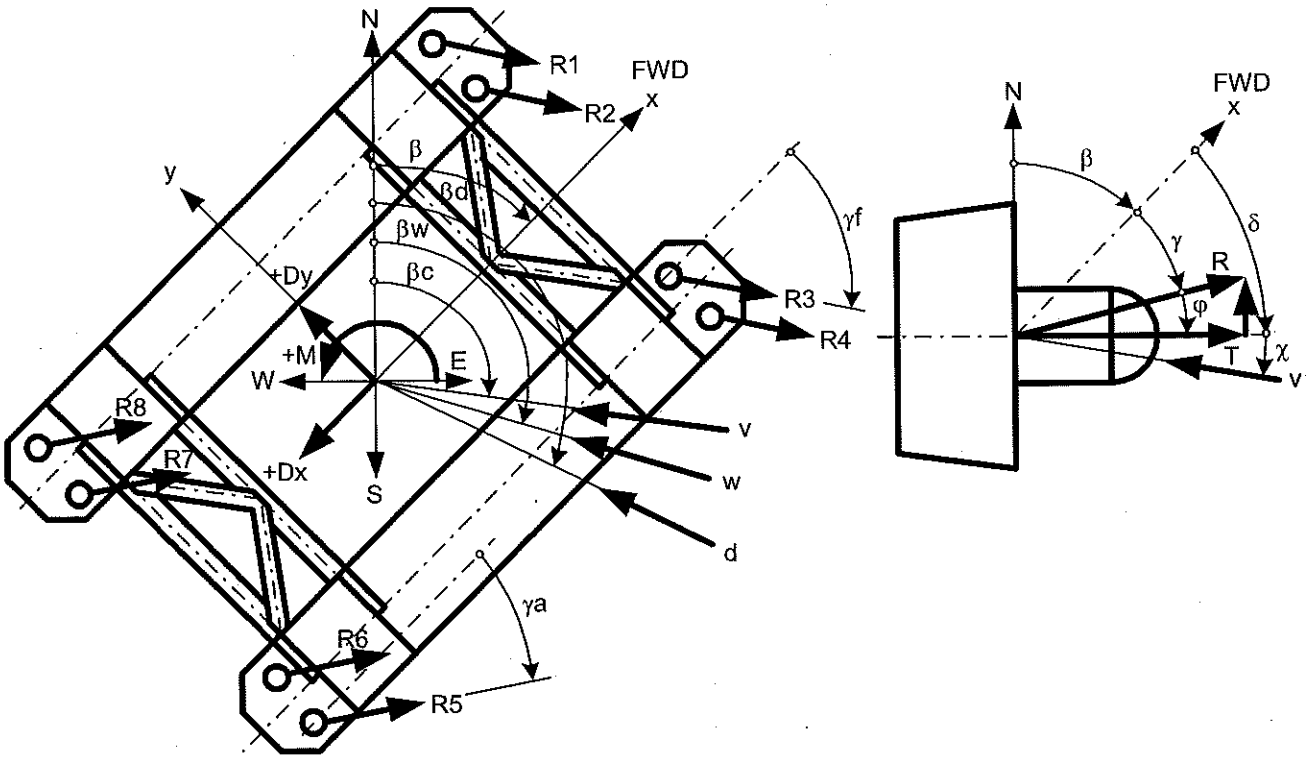


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Thrust Tv = 104.9 [kips] at current speed v

**Environmental Data**

v = 1.5 [knots] Current speed
w = 50.0 [knots] Wind speed
Hs = 19.0 [feet] Wave height
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Admissible draft range Dft = 23ft ... 65ft
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**PLOT C1-E4**

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**Incident Angle**

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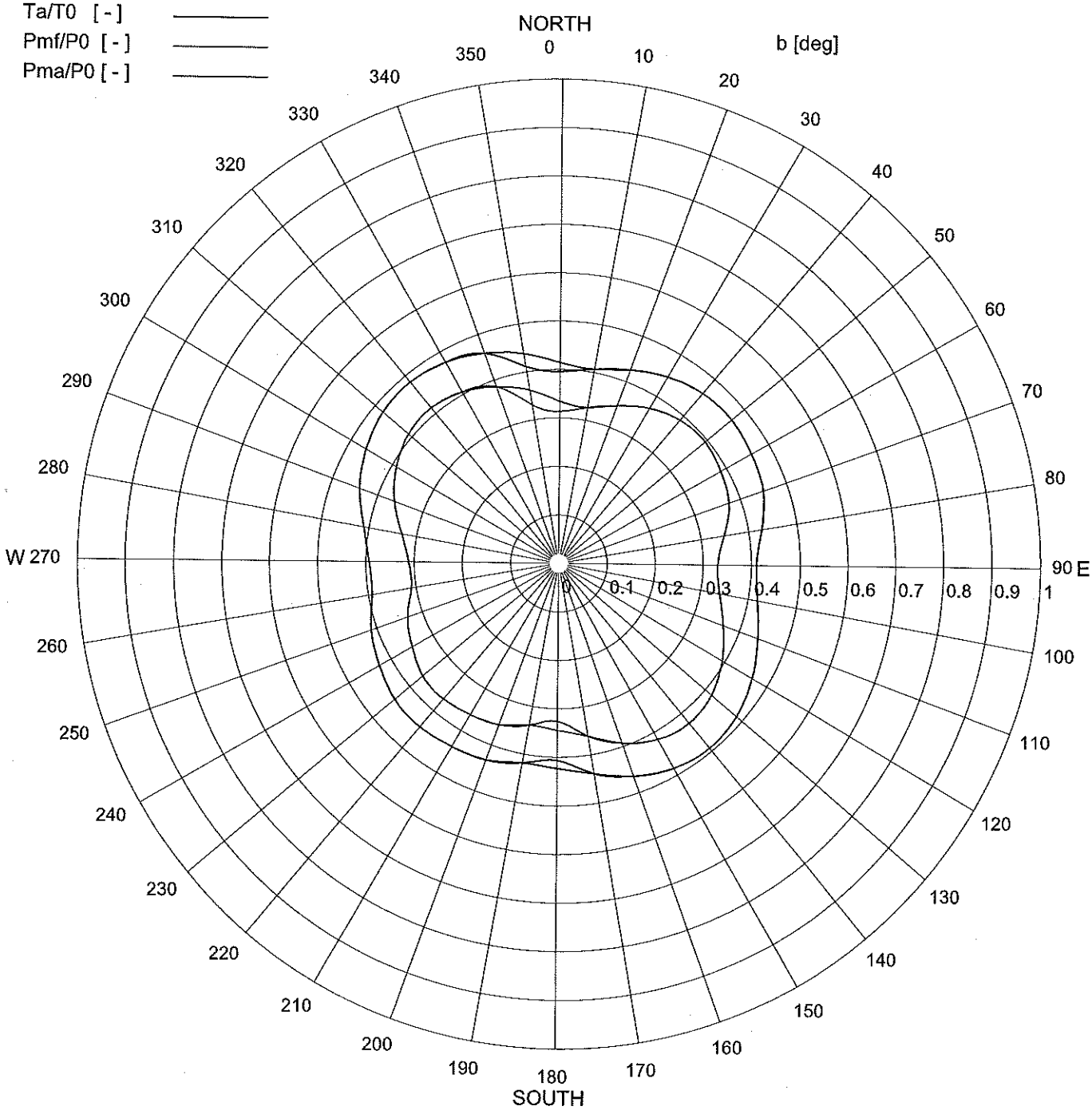

**PLOT C3-E1**

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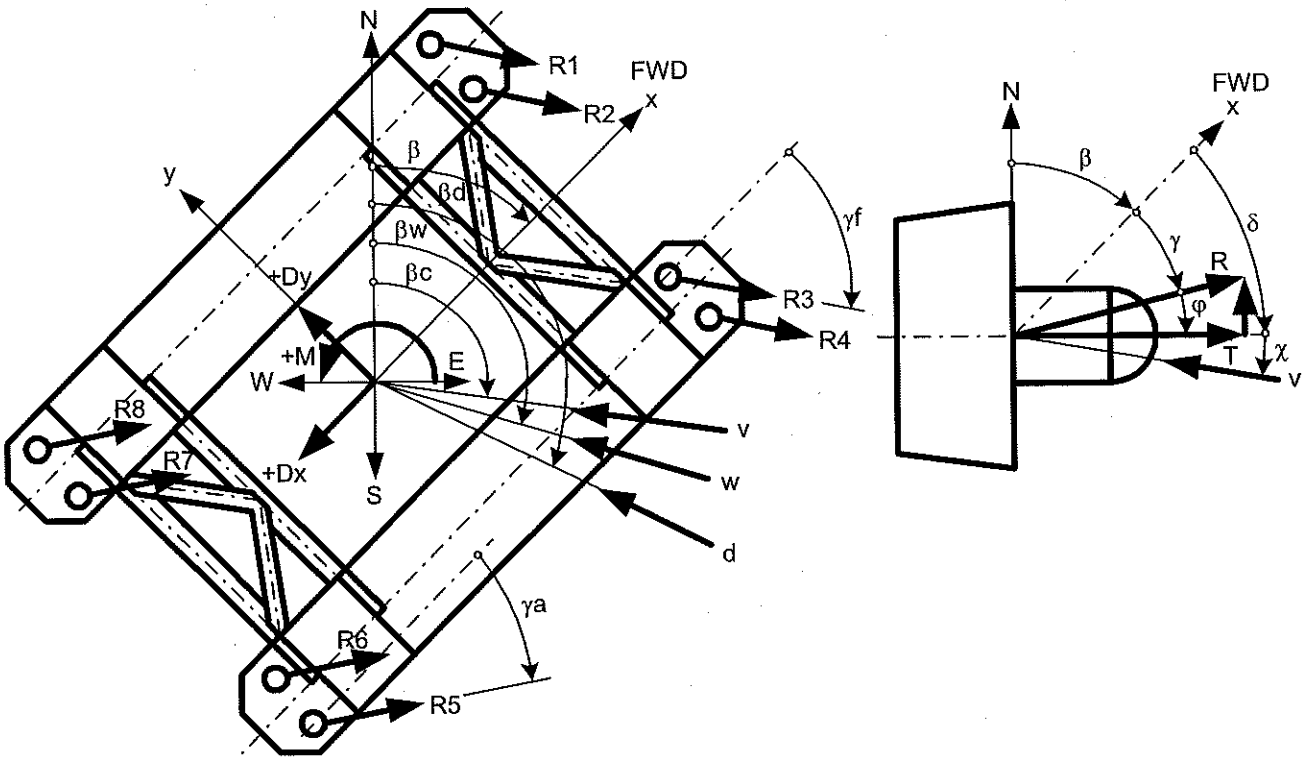


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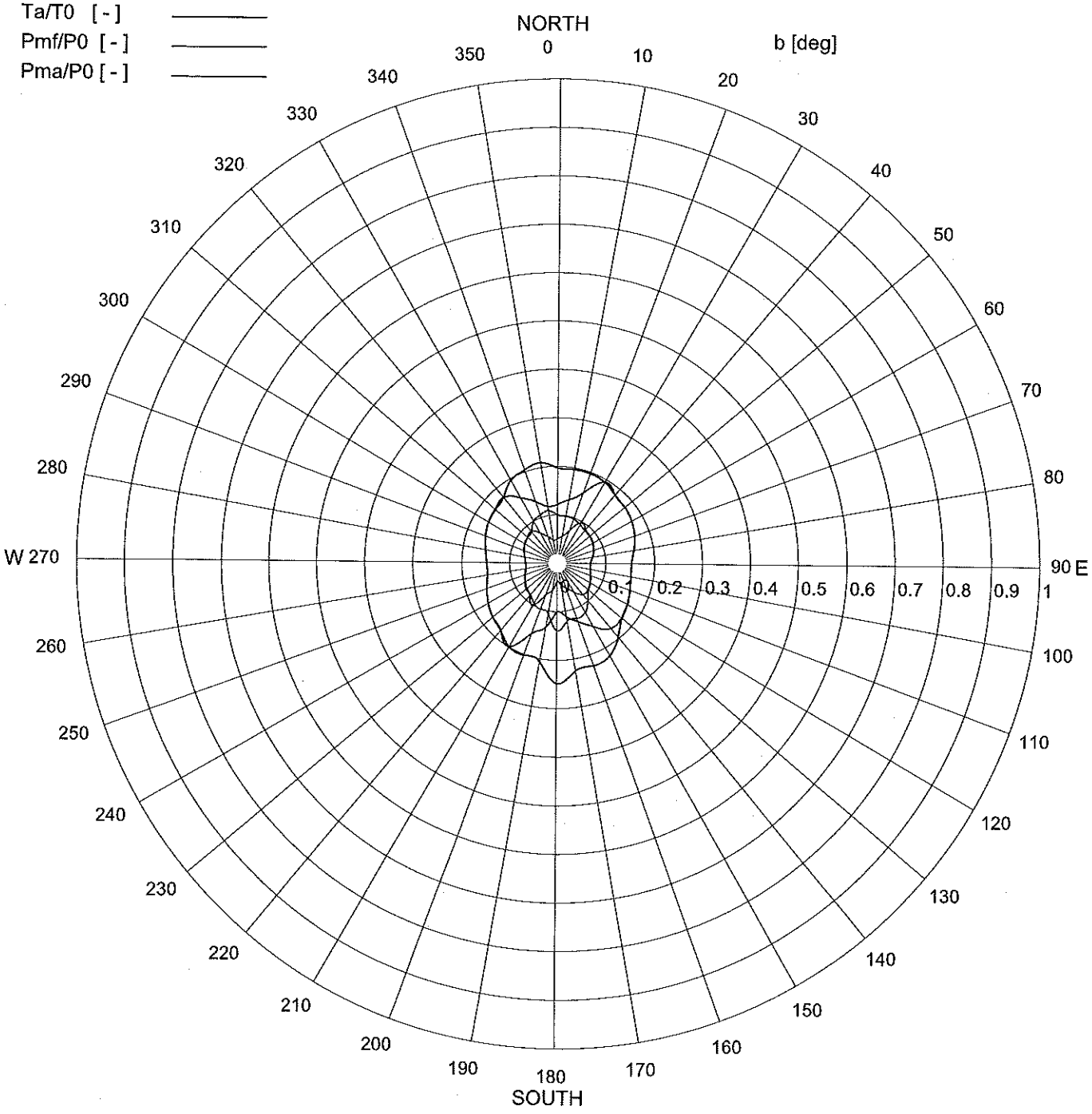
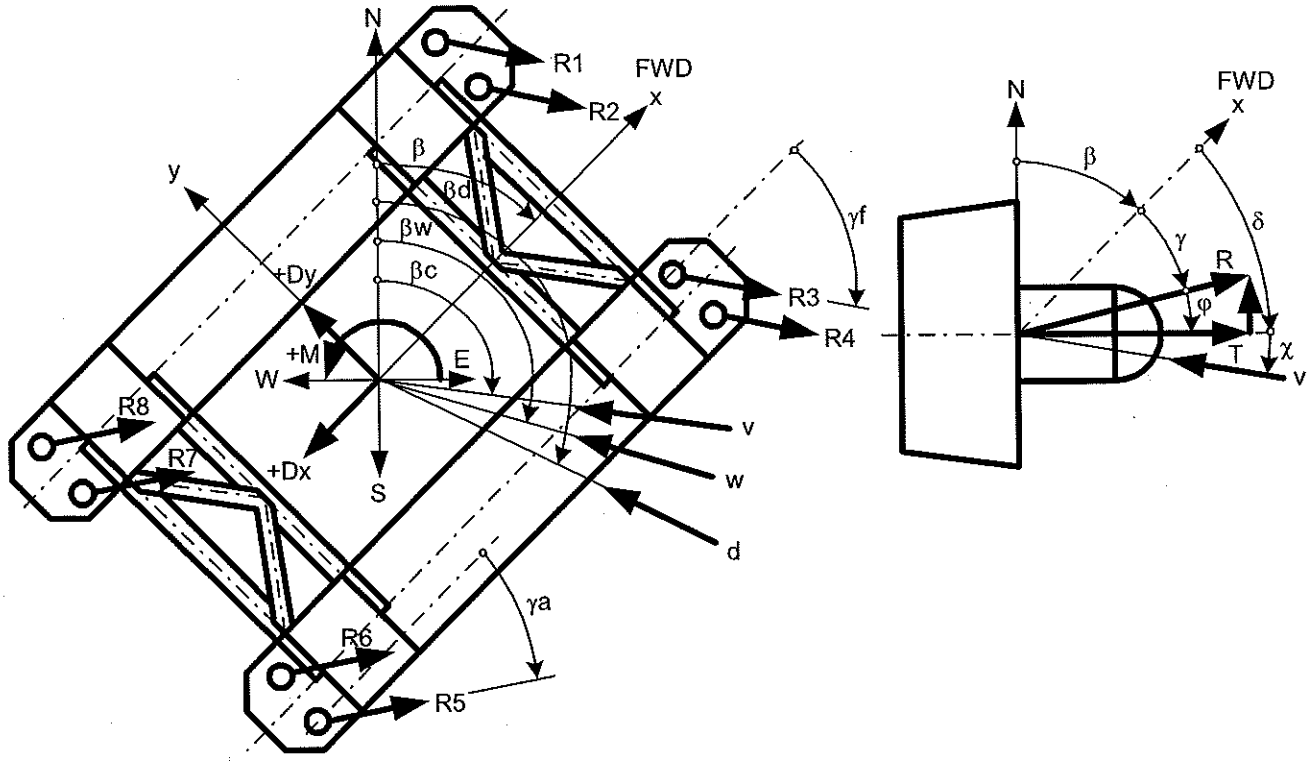


**PLOT C3-E4**

**Thruster Arrangement and Forces**

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